A multi-scaled analysis of urban American crow (*Corvus brachyrhynchos) winter roost* characteristics in Minnesota.

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Introduction

American Crow (*Corvus brachyrhynchos)* populations are increasing worldwide (Marzluff et al. 2001), with a documented movement of crow roosts from rural areas to urban centers. This shift highlights an increasing potential for human-crow conflict (Gorenzel et al. 2000) stemming from noisy crow vocalizations and concern over potential health risks associated with the large amounts of fecal droppings produced at roosts (Gorenzel and Salmon 1993). Though previous studies have quantified characteristics of urban crow roosts in Ohio (Haase 1963), California (Gorenzel and Salmon 1995), and New Jersey (Caccamise et al. 1997), no such efforts have been made in Minnesota. By combining a finer scale analysis through measuring roost characteristics identified by Gorenzel and Salmon (1995) and a broader-scale park to park comparison using GIS, I described characteristics of crow roosts in the Twin Cities. The results of this study can be used to inform management decisions as human conflicts with crows arise in the future.

Methods

Fine Scale Roost Measurements

To identify historic winter roost locations I searched eBird (Sullivan et al. 2009) data for observations of >100 crows made between October and February in the Twin Cities (MN) region. I limited the study to the area enclosed within the interstate 494/694 loop which is 8300 ha. From these observations, I selected the seven sites with the most occurrences of observations of >100 crows. I then selected seven random control sites (Fig. 1) by plotting these locations in ArcGIS and generating random points within 1km of the identified roost sites. At the control locations (Fig. 1), I selected the nearest tree that was >10cm diameter at breast height (DBH) to measure. At both the control and roost sites, I identified trees to genus and measured DBH, tree height using a Suunto Clinometer, and crown diameter in both the east-west and north-south direction. For canopy cover and night-time light levels, I took readings one meter out from the base of the tree in each cardinal direction using a spherical densiometer and a Dr. Meter digital lux meter, respectively. I characterized the substrate below the tree by taking five strides away from the base of each tree in each cardinal direction and classifying the ground below my feet as either impervious (bare soil or pavement) or pervious (turf or herbaceous) cover at each stride. I deployed iButton loggers >3m high in each tree to record temperatures every hour from 28 Nov 2014 to 4 Dec 2014.

Broad Scale Roost Comparisons

Using the same locations previously identified from eBird data, I compared broader scale aspects of roost parks including area, perimeter, and distance to water. I also calculated the edge to area ratio by dividing the perimeter by the area. Using data provided by the city of Minneapolis I compared urban tree canopy percent at both the park and greater neighborhood scale. I divided the percent canopy cover of the entire neighborhood by that of the individual park to determine how potentially valuable this resource is on the landscape; a lower quotient indicating a denser canopy than typically found in the neighborhood. Due to a more comprehensive GIS layer available for Minneapolis parks and the fact that six of my seven sites fell within Minneapolis city limits, I chose to limit the broader scale analysis to Minneapolis. To use as a comparison to these parks, I randomly selected six other parks that I could not identify as a having a roost in the past. I made spatial calculations using ArcMap v10.2 (ESRI 2013) and exported the data to JMP (JMP 2013) for analysis.

Statistical analyses

To identify important roost characteristics at both scales I calculated oneway t-tests for each variable by roost/nonroost classification using JMP software (JMP 2013). Using the standard least squares method of logistic regression with an emphasis on effect screening I built models for both fine scale variables and broad scale variables. This allowed me to rank the variables by how well they predicted whether a site was a roost or nonroost.

Results

Fine Scale Roost Characteristics

Six out of seven roost sites fell within Minneapolis city limits (Fig 1). Four tree genera composed the seven roost sites: oak (Quercus, n=2), basswood (Tilia, n=2), maple (Acer, n=2) and elm (Ulmus, n=1). Roost trees had a mean height of 24.1m, DBH of 100 cm, crown diameter of 21.5m. Roost trees were on average 11.1 m taller (P=0.0112) than nonroost trees and 56 cm greater in DBH (P=0.0045). Percent canopy cover at roost trees was 26% greater (P=0.0034) than nonroost trees and crown diameter was 12.1 m greater (P=0.0022). Minimum temperatures were 1.4 ⍰ greater at roost sites compared to nonroost sites (P=0.075). The substrate composition below roost trees was nearly the same at nonroost trees, having only 0.05% greater pervious surface (P=0.6355). The log of nighttime light levels was 0.4 lumens less for roost trees than nonroost trees (P=0.152) Using the sum of least squares method of logistic regression I determined nighttime light levels best explained whether a tree was a roost or nonroost (P= 0.1454). In decreasing importance were: crown diameter, minimum temperature, percent pervious substrate, tree height and DBH (Table 1).

Broad Scale Roost Characteristics

I found the edge:area ratio to be an average of 179.2 units less for roosts than nonroosts (P=0.0502). Parks with roosts were on average 7.77 ha which is 2.394 ha larger than randomly selected parks (P=0.517). The average roost park perimeter was 869 m shorter than nonroost parks on average (P=0.504). Canopy cover of roost parks was 12% greater on average than at random parks (P=0.224). The ratio of neighborhood percent canopy cover/ park percent canopy cover was 0.6547 less for roost parks than nonroost parks (P=0.0759). Roost parks had a mean edge:area ratio 222.5 m/ha with nonroost parks being 179.2 m/ha larger (P=0.0502). Distance to water did not differ significantly between roost and random parks, though roost parks were 290 m closer to water on average (P=0.503). Using the sum of least squares method of logistic regression I determined that neighborhood percent canopy cover/ park percent canopy cover best explained whether a park contained a roost or not (P=0.021). In order of decreasing effect following the previous ratio were: edge:area, percent canopy, percent neighborhood canopy, perimeter, area and distance to water (Table 2).

Discussion

Consistent with Gorenzel and Salmon (1995), I found roost trees to be larger in every aspect compared to nonroost trees. Unlike their same study though, I found nighttime light levels to be lower at roosts than nonroosts. Preference for higher nighttime light levels has been attributed to an increased ability to detect predators (Gorenzel and Salmon 1995), and so my differing result may indicate a release from typical predators like the great horned owl (*Bubo virginianus*) in a highly urbanized area. This finding highlights the importance of carrying out similar research in a wide range of geographic locations.

By dividing the percent canopy cover of an entire neighborhood by the percent canopy cover of roost and randomly selected parks, I determined this ratio was smaller for roosts. A smaller number indicates that a park has a denser canopy than is typically found in the neighborhood implying that crows seek these areas when selecting a roost. I found that the edge:area ratio is smaller for roost parks than randomly selected parks in the study area. This may indicate a roosting preference for more square-shaped parks with minimal intrusion into park land by roads and residences. Identifying such areas through use of GIS will assist managers in locating candidate roost sites.

Using public data for research can be a powerful tool that allows researchers access to datasets larger than any individual or team could collect. With this in mind it is necessary to acknowledge the limitations of such an approach. Biases may result if more data contributors spend more time in certain areas as this may lead to incorrect conclusions about what areas are most important to an animal. Likewise, a lack of users in an area could cause a failure to identify an important area to a population. Though I did not statistically test for any difference, as I reviewed hundreds of observations from over the past seven years I consistently observed contributions from all across the metropolitan area and therefore feel no single area has been neglected from analysis.

In order to expand upon this study in the future and maximize its usefulness to managers I recommend the following adjustments. By extending the length of the study, monitoring movement between roosts throughout the entire cold-weather season would become possible. This may reveal patterns unobservable when temporal use is ignored. Also, by locating more roosts the statistical power of the study could be increased by having a larger sample size. While some insight can be gained from fine-scale measurements at single trees, I believe a broader view of roost selection is also beneficial to managers, considering that large communal roosts involve multiple trees that may vary in size and species. I therefore stress the importance of using a multi-scale approach when studying such highly mobile animals.

Based on this study, urban crows roost at sites that 1.) have trees that are larger in diameter and height, 2.) are within parks having a smaller edge:area ratio 3.) are in areas within neighborhoods that have the densest canopies 4.) are warmer and 5.) have lower nighttime light levels than are typically found in the Twin Cities metropolitan area. This suggests that researchers investigating the management of urban crows should focus their attention on these areas to maximize their efforts.

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Table 1. Summary of results from least squares regression of fine scale variables.

Term	Estimate	Std Error	t Ratio	Prob>|t|
Log Light	-0.322117	0.196641	-1.64	0.1454
Crown Diameter	0.0506667	0.038314	1.32	0.2276
Temp Min	-0.144824	0.124615	-1.16	0.2833
Percent Pervious	-0.620896	0.608974	-1.02	0.3419
Tree Height	0.0088666	0.02065	0.43	0.6806
DBH	0.0029569	0.010806	0.27	0.7923

Table 2. Summary of results from least squares regression of broad scale variables.

Term	Estimate	Std Error	t Ratio	Prob>|t|
Neighborhood canopy : park canopy	-1.390029	0.376496	-3.69	0.021
Edge:area	-3.60E-03	0.001143	-3.15	0.0346
Canopy	-0.038646	0.01495	-2.59	0.061
Neighborhood Canopy	3.06E-02	0.015571	1.97	0.1205
Perimeter	0.0001155	0.000107	1.08	0.34
Area	-0.029363	0.031172	-0.94	0.3995
Distance to water	-5.19E-05	0.00014	-0.37	0.7305

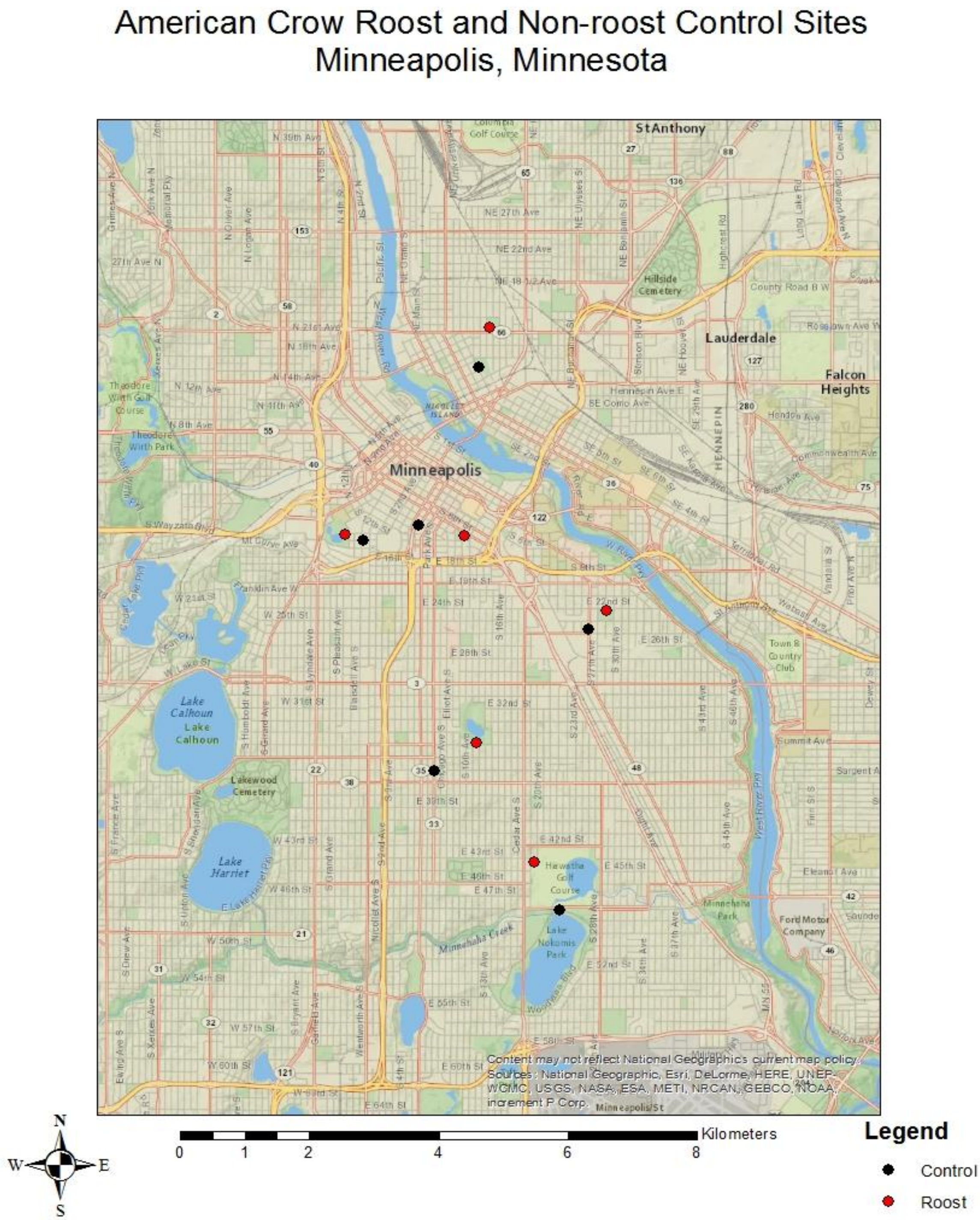

Figure 1. Locations of six out of seven American crow roost-control pairings, Minneapolis, Minnesota. Seventh site left out to enhance resolution as it was located 13.5km from the next nearest site.